REMARKS

This response is being submitted within four months of the mailing date of the Office Action outstanding. A Request for a One Month Time Extension is enclosed herewith. Applicants request the fee for the Time Extension Request be deducted from Applicants' Deposit Account No. 19-1457.

By this Response, claims 9 and 22 have been amended. Claims 1-2, 4-12 and 21-22 are pending in the application. Claims 1, 9 and 21 are in independent form. No claim fees are required for this amendment.

In the Office Action dated June 5, 2003, the Examiner suggested that new drawings be submitted. Applicants will submit new drawings upon allowance of the pending claims.

In the Office Action dated June 5, 2003, the Examiner objects to the specification in stating that the specification at page 3, line 9, recites an "atmosphere chosen from the group consisting of" whereas claim 22 recites an "atmosphere is chosen from the group consisting *essentially* of." (italics in original). By this amendment Applicants have amended claim 22 to conform to the specification by deleting the term "essentially."

Danek Reference: In the Office Action dated June 5, 2003, the Examiner rejects claims 1, 2, 4, 5 and 8 under 35 USC 102(e) as allegedly being anticipated by Danek et al. (U.S. Pat. No. 6,534,404) (hereinafter "Danek"). Applicants respectfully disagree.

Applicants' independent claim 1 recites a method of treating a barrier metal layer after the layer has been previously deposited on an integrated circuit

device. In particular, Applicants recite "providing a partially finished integrated circuit device including a barrier metal layer." (emphasis added). This previously deposited barrier metal layer is subjected "to a non-plasma atmosphere chosen from the group consisting of: an ambient vacuum, hydrogen gas, argon gas and helium gas" and "to a temperature greater than 200 degrees Celsius for at least thirty seconds." Danek does not teach or suggest any of these three steps of Applicants' process.

First, Danek discloses a "method for depositing diffusion barriers." (column 1, lines 60-61; column 1, lines 66-67; column 2, lines 3-5; column 2, line 12; column 2, lines 24-27; column 2, lines 39-41; column 2, lines 61-62; column 2, lines 63-64; column 2, line 66; column 3, lines 14-15; column 3, lines 17-18; and column 3, line 48). The entire specification of Danek is devoted to the formation/deposition of the barrier metal layer, and not to a subsequent treatment of a previously deposited barrier layer. Accordingly, Danek does not teach or suggest "providing a partially finished integrated circuit device including a barrier metal layer," (emphasis added) for subsequent treatment, as recited in Applicants' claim 1.

Second, Danek discloses a deposition process utilizing silane, disilane and/or trisilane. In particular, at several times during formation, i.e., during deposition, of the barrier layer, Danek provides a silane (SiH_4) atmosphere to deposit a "multilayer TiN(Si) barrier 36 composed of alternating layers of TiN, sublayers 32a-32e, and silicon rich material, sublayers 34a-34e." (column 3, lines 45-47). No where in th Dan k reference does Danek teach or suggest subj cting a previously deposited barri r layer "to a non-plasma atmosphere chosen from the

group consisting of: an ambient vacuum, hydrogen gas, argon gas and helium gas," as recited in Applicants' claim 1.

Third, Danek states at column 3, lines 24-31, that during deposition of their barrier layer, the "transition metal nitride film is thermally treated in-situ in a gas containing silicon. The thermal treatment step is conducted at low pressure to create an ultrathin, continuous layer of silicon rich material over the binary transition metal nitride. The reaction chamber is again purged in step 20. Steps 14, 16, 18 and 20 are repeated until the desired number of layers have been formed. The substrate is then unloaded from the deposition system in step 22." (emphasis added). In contrast to the Examiner's assertion, this above listed paragraph of Danek does not teach or suggest Applicants' step of subjecting a previously deposited barrier metal layer "to a temperature greater than 200 degrees Celsius for at least thirty seconds." The disclosed thermal treatment disclosed above by Danek is conducted during deposition of the barrier metal layer, not after formation thereof. Moreover, in contrast to the Examiner's assertion, Danek's mere mention of a "thermal process" does not teach specific temperatures, and does not disclose "a temperature greater than 200 degrees Celsius for at least thirty seconds," as recited in Applicants' claim 1.

In summary, the Examiner is improperly mischaracterizing the Danek reference. Danek discloses a deposition method of creating a multilayer barrier metal film having alternating layers of TiN and silicon rich sublayers therein by providing a silicon rich atmosphere during deposition of the barrier metal layer. (column 3, lines 40-47). Danek does not teach or suggest Applicants' method of treating a previously deposited barrier metal layer "to a non-plasma atmosph re

chosen from th group consisting of: an ambient vacuum, hydrogen gas, argon gas and helium gas" and "to a temperature greater than 200 degrees Celsius for at least thirty seconds." Accordingly, Applicants request the Examiner to withdraw the rejection of independent claim 1, and corresponding dependent claims 2, 4, 5 and 8, under 35 USC 102(e).

In the Office Action dated June 5, 2003, the Examiner rejects dependent claim 6 under 35 USC 103(a) as allegedly being unpatentable over Danek, and rejects dependent claim 7 under 35 USC 103(a) as allegedly being unpatentable over Danek in view of Van et al. (U.S. Pat. No. 6,567,541) (hereinafter "Van"). Claims 6 and 7 are dependent on independent claim 1. For the above listed reasons, Applicants believe claim 1 is not taught or suggested by Danek. Van fails to supplement the shortcomings of Danek. Accordingly, Applicants believe dependent claims 6 and 7 are not taught or suggested by Danek, alone or in combination with Van, and Applicants respectfully request the Examiner to withdraw the rejection of claims 6 and 7 under 35 USC 103(a).

McTeer Reference. In the Office Action dated June 5, 2003, the Examiner rejects claims 1, 2, 5, 6, 8, 9, 11, 21 and 22 under 35 USC 102(e) as allegedly being anticipated by McTeer et al. (U.S. Pat. No. 6,204,179) (hereinafter "McTeer"). Specifically, the Examiner states that McTeer teaches subjecting a barrier metal layer to a non-reactive atmosphere such as hydrogen. Applicants respectfully disagree.

Applicants' independent claims 1, 9 and 21 each recite a method of treating a barrier metal layer in a non-reactiv or a non-plasma atmosphere, for xample, hydrogen gas. In particular, independent claim 1 recites "subjecting said barrier

metal layer to a non-plasma atmosphere chosen from the group consisting of: an ambient vacuum, hydrogen gas, argon gas and helium gas." Independent claim 9 as amended recites "subjecting said barrier metal layer to . . . a non-plasma atmosphere chosen from the group consisting of: an ambient vacuum, Hydrogen gas, Argon gas, and Helium gas." Independent claim 21 recites "subjecting said barrier metal layer to . . . a non-reactive atmosphere." McTeer does not teach or suggest subjecting a barrier metal layer to a non-reactive atmosphere as recited in Applicants' claims 1, 9 and 21.

McTeer discloses a method to increase the diffusion barrier capabilities of a TiAlN layer by doping the barrier layer in a reactive atmosphere such as oxygen. "In order to increase the diffusion barrier capabilities of the $Ti_xAl_yN_z$ barrier layer 2, the $Ti_xAl_yN_z$ barrier layer 2 may optionally be annealed in an oxygen atmosphere by subjecting the silicon substrate so formed to rapid thermal processing (RTP) while flowing in oxygen at a temperature of less than 700°C for less than 5 minutes prior to the deposition of copper 3, thereby doping the $Ti_xAl_yN_z$ barrier layer 2 with oxygen or an oxygen species O_m wherein m is great than or equal to 1." (column 17, lines 40-48). After the rapid thermal process of doping the barrier layer in an oxygen atmosphere, "Copper [layer] 3 is then hot deposited at a temperature of approximately 450° C. to approximately 550° C. by a PVD sputter to a thickness which is sufficient to fill the opening." (column 17, lines 48-51). "The copper layer is then annealed by subjecting the silicon substrate so formed to an elevated temperature in a vacuum for a period of time less than 5 minutes. Alternatively, the anneal may be carried out by flowing in gases, such as hydrogen. After annealing, the copper is th n caused to reflow at a t mperature

gr ater than about 500° C. by techniques well known to one of ordinary skill in the art." (column 17, 51-58). According, McTeer discloses doping the barrier metal layer in a reactive oxygen atmosphere and then, in column 17, line 55, McTeer discloses subjecting the subsequently deposited copper layer to a hydrogen atmosphere. The Examiner incorrectly states "McTeer teach [subjecting a barrier layer to] a hydrogen gas in line 55, column 17." Moreover, even if McTeer's barrier layer were subjected to a hydrogen atmosphere, subjecting McTeer's barrier layer to a hydrogen atmosphere would not result in doping of the barrier layer, thereby defeating the entire purpose of the McTeer method.

McTeer does not teach or suggest Applicants' method of treating a previously deposited barrier metal layer to a non-reactive or a non-plasma atmosphere such as hydrogen, as recited in Applicants' Independent claims 1, 9 and 21. Accordingly, Applicants request the Examiner to withdraw the rejection of independent claims 1, 9 and 21, and corresponding dependent claims 2, 5, 6, 8, 11 and 22, under 35 USC 102(e).

Itoh Reference. In the Office Action dated June 5, 2003, the Examiner rejects claims 9-12 under 35 USC 103(a) as allegedly being unpatentable over Itoh et al. (U.S. Pat. No. 6,455,421) (hereinafter "Itoh") in view of Nguyen et al. (U.S. Patent No. 5,851,367) (hereinafter "Nguyen"). Itoh discloses subjecting a barrier layer to a reactive "plasma." Applicants claim 9 recites subjecting a barrier layer to a "gas." As discussed in prior responses to the Examiner, Applicants' "gas" is very different than the reactive "plasma" taught by Itoh. Nevertheless, Applicants hav amended claim 9 to recite "subjecting said barrier metal layer to . . . a non-plasma atmosphere chosen from the group consisting of: an ambient

vacuum, Hydrogen gas, Argon gas, and Helium gas." (emphasis added). Itoh does not teach or suggest subjecting a barrier metal layer to "a non-plasma atmosphere chosen from the group consisting of: an ambient vacuum, Hydrogen gas, Argon gas, and Helium gas" as recited in Applicants' claim 9. Nguyen fails to supplement the shortcomings of Itoh. Accordingly, Applicants request the Examiner to withdraw the rejection of independent claim 9 as amended, and corresponding dependent claims 10-12, under 35 USC 103(a).

Tsai Reference. In the Office Action dated June 5, 2003, the Examiner rejects claims 21-22 under 35 USC 103(a) as allegedly being unpatentable over Tsai et al. (U.S. Pat. No. 6,429,115) (hereinafter "Tsai"). In particular, the Examiner states "since the cap can serve as the barrier layer the pre-treatment would serve the barrier layer." However, neither the treatment of the barrier layer or the cap layer of Tsai teaches or suggests Applicants' process as recited in independent claim 21.

Applicants' independent claim 21 recites the following three steps: first, "providing a partially finished integrated circuit device including a barrier metal layer;" second, "subjecting said barrier metal layer . . . to a non-reactive atmosphere;" and third, "depositing a copper film on said pre-treated barrier metal layer." Tsai does not teach or suggest conducting these three steps on either their barrier or their cap layer.

Tsai discloses depositing a cap layer 106 on a dielectric layer 102. (column 4, lines 11-12). The cap layer 106 is then subjected to a reactive nitrogen "plasma." (column 4, lines 21-25). An adhesion promotion lay r 112 is then coated ov r the plasma treated surface 110 of cap lay r 106. (column 4, lines 30-

31). Accordingly, Tsai does not teach or suggest treating their cap layer 106 with a "non-reactive gas" or depositing "a copper film" on their cap layer, as recited in Applicants' claim 21.

Tsai goes on to disclose that a second dielectric layer 114 is then formed on adhesion promoter layer 112. (column 4, lines 44-45). A barrier layer 116 is formed over second dielectric layer 114. (column 54-56). A conductive layer 118 is formed over barrier layer 116. (column 4, lines 60-65). Tsai does not teach or suggest any treatment process of barrier layer 116 prior to deposition of conductive layer 118 thereon. Accordingly, Tsai does not teach or suggest subjecting their barrier layer 116 to "a temperature greater than 200 degrees Celsius, while said barrier metal layer is subjected to a non-reactive atmosphere, for at least thirty seconds to form a pre-treated barrier metal layer" prior to deposition of a copper film thereon, as recited in Applicants' claim 21.

Tsai does not teach or suggest the process of Applicants' claim 21 for either of Tsai's barrier or cap layers. Accordingly, Applicants request the Examiner to withdraw the rejection of independent claim 21, and corresponding dependent claim 22, under 35 USC 103(a).

In view of the above noted amendments and remarks this application is believed to be in condition for allowance and notice thereof is respectfully solicited. The Examiner is urged to contact Applicants' attorney at the number listed below if there are any questions.

Applicants respectfully request entry of this Amendment and consideration of the application as amended.

Respectfully submitted,

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